(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 684 017 B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
24.02.1999 Bulletin 1999/08

(51) Int. Cl.[6]: **A61B 17/58**

(21) Application number: **95106593.7**

(22) Date of filing: **02.05.1995**

(54) **Bone plate**
Knochenplatte
Plaque d'ostéosynthèse

(84) Designated Contracting States:
CH DE ES FR GB IT LI SE

(30) Priority: **24.05.1994 US 249238**

(43) Date of publication of application:
29.11.1995 Bulletin 1995/48

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Description

[0001] This invention relates to a bone plate according to the preamble of claim 1.

[0002] Strength reduction caused by stress concentration around screw holes of the bone plate utilized to lock the implant to the bone with screws or bolts can lead to failure of the implant. The conventional approach for improving the strength of the bone plate is to increase the dimensions of the critical section or add material around the hole.

[0003] A bone plate with a cross section which is decreased between the bore holes to achieve a bending resistance not more extensiv than in the region of the bore holes and with oval bore holes having longitudinal side walls with recesses to engage the head of the screw is disclosed in EP 0 318 762 (KLAUE) which is used as basis for the preamble of claim 1.

[0004] The disadvantages of these known modifications are increased invasiveness of the implant. Furthermore, in the surgical application for which the bone plates are designed, it is not always possible to increase the dimensions at the critical sections of the bone plate. A minimal amount of tissue disturbance would be desirable.

[0005] The invention as claimed aims at solving the above described problems by providing a plate having the same over-all dimensions with less material. The removal of material is effected at strategic locations of the bone plate in order to reduce the peak stresses.

[0006] With a beam (approximating the bone plate body) loaded in bending, the stresses can be reduced at the edge of the screw holes by bringing the hole closer to the neutral longitudinal axis of the beam. This is done by removing material from the surface of said upper side around said screw holes, e.g. by cutting a continuous or discontinuous longitudinal groove. The depth of the groove is optimized when the stresses at point A (edge of the screw hole) and point B (edge of the groove at the screw hole) are equal.

[0007] In a further embodiment of the invention - where transverse cuts are present on the under surface of the implant - the cross-section between the screw holes is not decreased. Therefore, the groove on the top surface is made discontinuous with smooth transition in and out of the hole.

[0008] In a further embodiment of the invention - where the undersurface of the bone plate has a concave shape - the height of contact between the screw hole and the bone plate was reduced along the longitudinal center line of the bone plate with a flat groove. Material should not be reduced along the longitudinal center line of the bone plate. With an optimized profile on a circular tool, an overcut is produced that permits a smooth transition into and out of the screw hole; reduces the stress along the edge of the screw hole; and maintains full contact height with the screw along the longitudinal center line of the bone plate.

[0009] The various features which characterize the invention are pointed out with particularity in the claims annexed to and forming part of this disclosure. For the better understanding of the invention, its operating advantages and specific objects attained by its use, reference should be had to the accompanying drawings, examples and descriptive matter in which are illustrated and described preferred embodiments of the invention.

[0010] In the drawings:

Fig. 1 is a schematic view of a fractured bone held together with a known bone plate;

Fig. 2 is a perspective view of a known bone plate;

Fig. 3 is a perspective view of a known bone plate with a longitudinal groove removed;

Fig. 4 is a perspective view of a bone plate not in accordance with the invention with short grooves only in the hole region;

Fig. 5 is a transverse section perpendicular to the longitudinal axis of the bone plate of Fig. 4 through the center of a screw hole

Fig. 6 is a transverse section of the bone plate according to the invention;

Fig. 7 perspective view, including transverse section through a plate hole with special over-cuts;

Fig. 8 is a lateral view of the bone plate of Fig. 7; and

Fig. 9 is a top view of the bone plate of Fig. 7.

[0011] Referring to Fig. 1, a conventional bone plate 1 for treatment of bone fractures 3 is fixed to the bone 2 by means of a number of screws 4. The bending moment - indicated by arrows 103 - applied to the bone 2 by muscle forces causes tension on one side of the bone 2 while the other side is loaded in compression. Typically, the plate 1 is applied to the tension side of the bone 2. Therefore, the plate 1 is loaded in either tension or a combination of bending and tension depending on the amount of contact between the bone 2 halves at point 100.

[0012] The plate 1 shown in Fig. 2 is loaded in bending as indicated by arrows 103. Longitudinal center line 104 of the plate 1 is shown on the top surface 6. Longitudinal sides of the plate 1 are indicated by numerals 105. The highest stresses occur at the furthest distance in a cross section from the neutral axis 5 which is at the top surface 6 or the bottom surface 7. The holes 8 cause stress concentrations at the edge of the holes 9 which increase the tensile stress on the upper surface 6 by a factor of between 2 to 3.

[0013] Referring to Fig. 3, the stresses can be reduced at the edge of the holes 9 by bringing the edge of the hole 9 closer to the neutral axis 5 of the cross section of the plate. A groove 10 cut into the plate 1 brings the edge of the hole 9 closer to the neutral axis 5. The depth of the groove is optimized when the stresses at point 101 (edge of hole 9) and point 102 (edge of groove 11 at hole) are equal. If the groove is made deeper than this, the loss in strength due to the decrease of the cross-sectional area 12 becomes more significant than the gain made by reducing the stress at the hole edge 9.

[0014] Fig. 4 shows a plate with transverse cuts 13 and a longitudinal cut 14 on the lower surface 7 to reduce contact between the plate and bone. Due to the transverse undercuts 13, the cross-section 15 between the holes is already significantly reduced and should not be decreased further by an additional groove 10 on the upper surface 6 as in the embodiment according to Fig. 3 .

[0015] Therefore, the groove on the upper surface 6 is made discontinuous into short segmental grooves 16 providing a smooth transition into and out of the holes 8.

[0016] As shown in Fig. 5, along the centerline 106 the height of contact between the screw and the hole 8 is less than the height 17 at the edge of the hole. This could lead to instability of the screw in the longitudinal axis of the plate. Therefore, material should not be removed along the longitudinal centerline of the plate.

[0017] With the optimized profile on a circular tool, the cross section shown in Fig. 6 is created. With this cross section, the height of contact 18 along the centerline 106 is at least equal to the height 17 at the edge of the hole.

[0018] An embodiment of the invention is shown in Figs. 7 - 9, wherein the plate is provided with special overcuts in the form of depressed areas 19 that permit a smooth transition into and out of the hole 8 and still reduce the stress along the edge of the hole 9. The depth of the recessed areas 19 should purposefully be in the range of 0.2 to 2.0 mm and are designed in such a way that maximum stress at remaining surface of said upper side near said holes is approximately equal to the maximum stress at edges of said holes within said depressed areas. The depth of the recessed areas (19) also gradually decreases towards said longitudinal center line (104) of the bone plate.

[0019] Referring to Fig. 9 curvature C_2 of the hole 8 is defined as the ratio $1/r_2$, where r_2 is the radius 20 of the hole 8. Correspondingly, curvature C_1 is equal to the ratio $1/r_1$, where r_1 is the radius 21 of the edge 11 of the depressed area 19. Distance between the edge 11 of the depressed area 19 and the edge 9 of the hole 8 is indicated by arrows 22 and should be less than 1.0 mm preferably in the range of 0.1 to 1.0 mm. Curvature C_1 should be smaller than 60%, preferably smaller than 10% of the curvature C_2. Span regions 25 are defined between the depressed areas 19 around the screw holes 8.

[0020] While the foregoing description and drawings represent the preferred embodiments of the present invention, it will be obvious for those skilled in the art that various changes and modifications may be made therein without departing from the scope of the present invention as defined in the appendent claims.

Claims

1. Bone plate (1) with an upper side (6), a lower side (7) for bone contact, two longitudinal sides (105), a longitudinal center line (104), a plurality of screw holes (8) extending from said upper side (6) to said lower side (7), whereby

   A) said screw holes (8) have curved edges (9), an area (19) of said upper side (6) around said screw holes (8) being depressed with respect to the rest of said upper side (6), said depressed area (19) having a curved edge (11);
   B) span regions (25) are defined between said screw holes (8) having said depressed areas (19), the depth of said depressed areas (19) gradually decreasing in the longitudinal direction towards said span regions (25); and
   C) said edges (11) of said depressed areas (19) extend approximately parallel to said longitudinal sides (105);
   characterized in, that
   D) said depth of said depressed areas (19) being dimensioned so that the maximum stress at the remainder of said upper side (6) near said holes (8) is essentially equal to the maximum stress at edges (9) of said holes (8) within said depressed areas (19) and in that said depth of said depressed areas (19) also gradually decreases towards said longitudinal center line (104) of the bone plate (1).

2. Bone plate according to claim 1, wherein said edge (11) of said depressed area (19) has a curvature C_1, which is less than 60% of the curvature C_2, of the edge (9) of said screw hole (8).

3. Bone plate according to claim 2, wherein said curvature C_1 is less than 10 % of C_2.

4. Bone plate according to one of the claims 1 to 3, wherein the distance (22) from the edge (11) of said depressed area (19) to the edge (9) of said screw holes (8) is less than 1 mm.

5. Bone plate according to one of the claims 1 - 4, wherein the lower surface (7) of the bone plate (1) has a concave shape.

6. Bone plate according to claim 5, and comprising

transverse cuts (13) on said lower side (7) of the bone plate (1).

7. Bone plate according to one of the claims 1 to 6, wherein the depth of said depressed areas (19) is in the range of 0,2 to 2,0 mm.

Patentansprüche

1. Knochenplatte (1) mit einer Oberseite (6), einer Unterseite (7) zur Anlage an den Knochen, zwei Längsseiten (105), einer longitudinalen Zentralachse (104), mehreren zwischen Oberseite (6) und Unterseite (7) verlaufenden Schraubenlöchern (8), wobei

   A) die Schraubenlöcher (8) gerundete Kanten (9) aufweisen, auf der Oberseite (6) ein sich um die Schraubenlöcher (8) erstreckender Bereich (19) gegenüber dem Rest der Oberseite (6) vertieft ist, der erwähnte Bereich (19) eine gerundete Kante (11) aufweist;
   B) Zwischenbereiche (25) zwischen den mit vertieften Bereichen (19) versehenen Schraubenlöchern (8) definiert sind, die Tiefe dieser vertieften Bereiche (19) in der Längsrichtung gegen die Zwischenbereiche (25) allmählich abnimmt; und
   C) die Kanten (11) der vertieften Bereiche (19) sich annähernd parallel zu den Längsseiten (105) erstrecken;
   dadurch gekennzeichnet, dass
   D) die Tiefe der vertieften Bereiche (1) so dimensioniert sind, dass die Maximalspannung am Rest der Oberseite (6) in der Nähe der Schraubenlöcher (8) im wesentlichen der Maximalspannung an den Kanten (9) der Schraubenlöcher (8) innerhalb des vertieften Bereiches (19) entspricht und, dass die Tiefe der vertieften Bereiche (19) ebenfalls in Richtung der longitudinalen Zentralachse (104) der Knochenplatte (1) allmählich abnimmt.

2. Knochenplatte nach Anspruch 1, dadurch gekennzeichnet, dass die Kante (11) des vertieften Bereiches (19) eine Krümmung C_1 aufweist, welche weniger als 60% der Krümmung C_2 der Kante (9) des Schraubenloches (8) beträgt.

3. Knochenplatte nach Anspruch 2, dadurch gekennzeichnet, dass die Krümmung C_1 weniger als 10% von C_2 beträgt.

4. Knochenplatte nach einem der Ansprüche 1 bis 3, dadurch gekennzeichnet, dass die Distanz (22) von der Kante (11) des vertieften Bereiches (19) zur Kante (9) der Schraubenlöcher (8) weniger als 1 mm beträgt.

5. Knochenplatte nach einem der Ansprüche 1 bis 4, dadurch gekennzeichnet, dass die Unterseite (7) der Knochenplatte (1) eine konkave Gestalt aufweist.

6. Knochenplatte nach Anspruch 5, dadurch gekennzeichnet, dass sie Querkerben (13) auf der Unterseite (7) der Knochenplatte (1) umfasst.

7. Knochenplatte nach einem der Ansprüche 1 bis 6, dadurch gekennzeichnet, dass die Tiefe der vertieften Bereiche (19) im Bereich zwischen 0,2 bis 2,0 mm liegt.

Revendications

1. Plaque pour os (1) présentant un côté supérieur (6), un côté inférieur (7) prévu pour le contact avec l'os, deux côtés longitudinaux (105), une ligne centrale longitudinale (104), plusieurs trous (8) pour vis s'étendant entre ledit côté supérieur (6) et ledit côté inférieur (7), dans laquelle

   A) lesdits trous (8) pour vis présentent des bords (9) incurvés, une zone (19) dudit côté supérieur (6) entourant lesdits trous (8) pour vis étant en creux par rapport au reste dudit côté supérieur (6), ladite zone (19) en creux présentant un bord (11) incurvé;
   B) des régions (25) assurant la portée sont définies entre lesdits trous (8) pour vis présentant lesdites zones en creux (19), la profondeur desdites zones en creux (19) diminuant progressivement dans la direction longitudinale en direction desdites régions (25) assurance la portée; et
   C) lesdits bords (11) desdites zones en creux (19) s'étendent approximativement parallèlement auxdits côtés longitudinaux (105);
   caractérisée en ce que
   D) ladite profondeur desdites zones en creux (19) est dimensionnée de telle sorte que la contrainte maximale sur le reste dudit côté supérieur (6) à proximité desdits trous (8) est essentiellement égale à la contrainte maximale sur les bords (9) desdits trous (8) dans lesdites zones en creux (19), et en ce que ladite profondeur desdites zones en creux (19) diminue également progressivement en direction de ladite ligne centrale longitudinale (104) de la plaque pour os (1).

2. Plaque pour os selon la revendication 1, dans laquelle ledit bord (11) de ladite zone en creux (19) présente une courbure C_1 qui vaut moins de 60% de la courbure C_2 du bord (9) dudit trou pour vis (8).

3. Plaque pour os selon la revendication 2, dans

laquelle ladite courbure C_1 est inférieure à 10% de C_2.

4. Plaque pour os selon l'une des revendications 1 à 3, dans laquelle la distance (22) entre le bord (11) de ladite zone en creux (19) et le bord (9) desdits trous (8) pour vis est inférieure à 1 mm.

5. Plaque pour os selon l'une des revendications 1 à 4, dans laquelle la surface inférieure (7) de la plaque pour os (1) présente une forme concave.

6. Plaque pour os selon la revendication 5, et comportant des découpes transversales (13) sur ledit côté inférieur (7) de la plaque pour os (1).

7. Plaque pour os selon l'une des revendications 1 à 6, dans laquelle la profondeur desdites zones en creux (19) est comprise dans la plage de 0,2 à 2,0 mm.

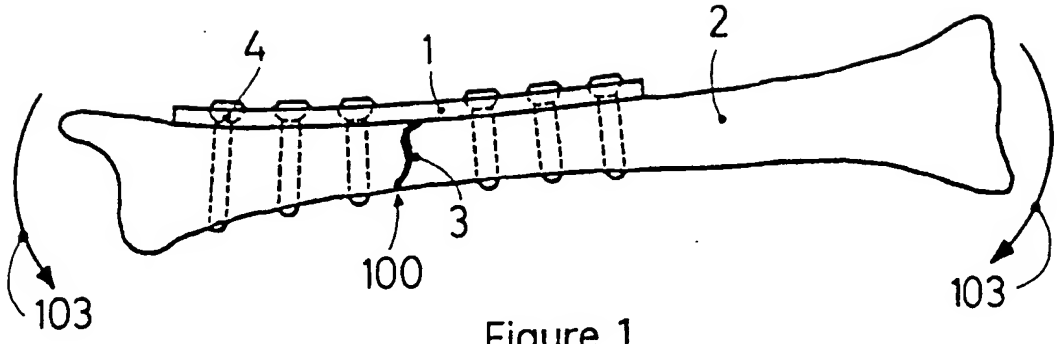

Figure 1

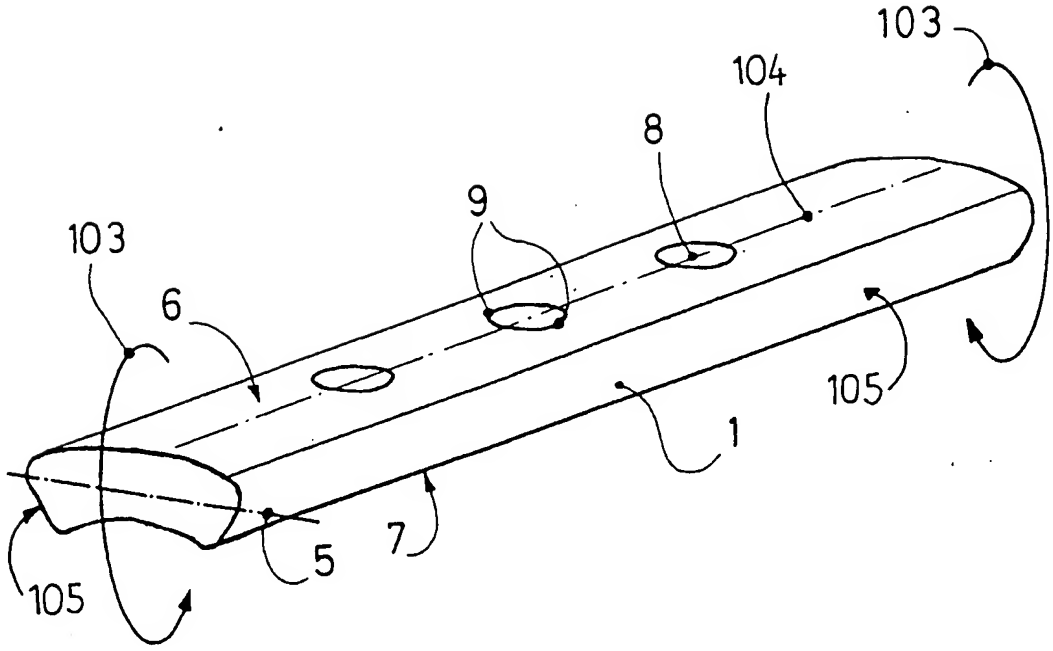

Figure 2

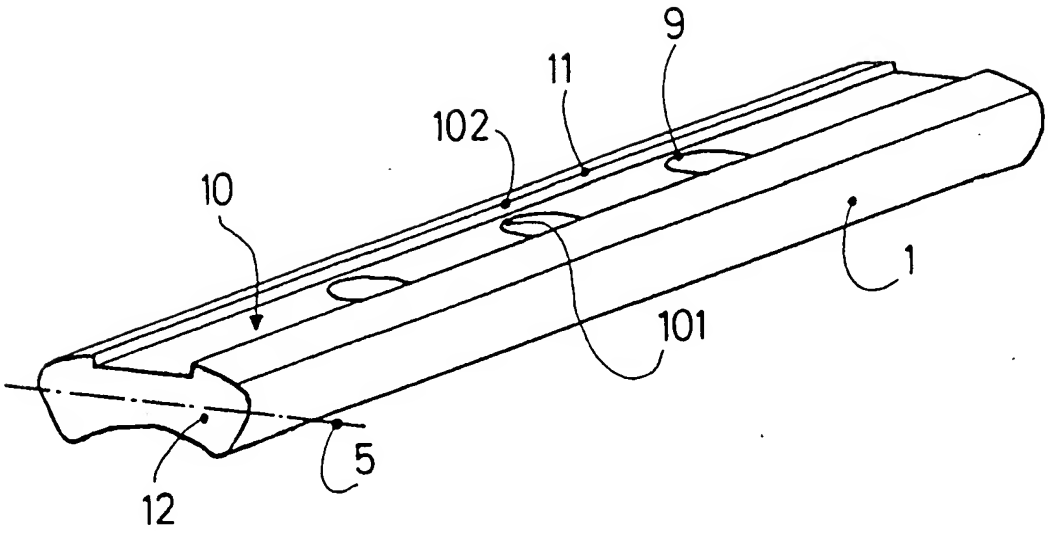

Figure 3

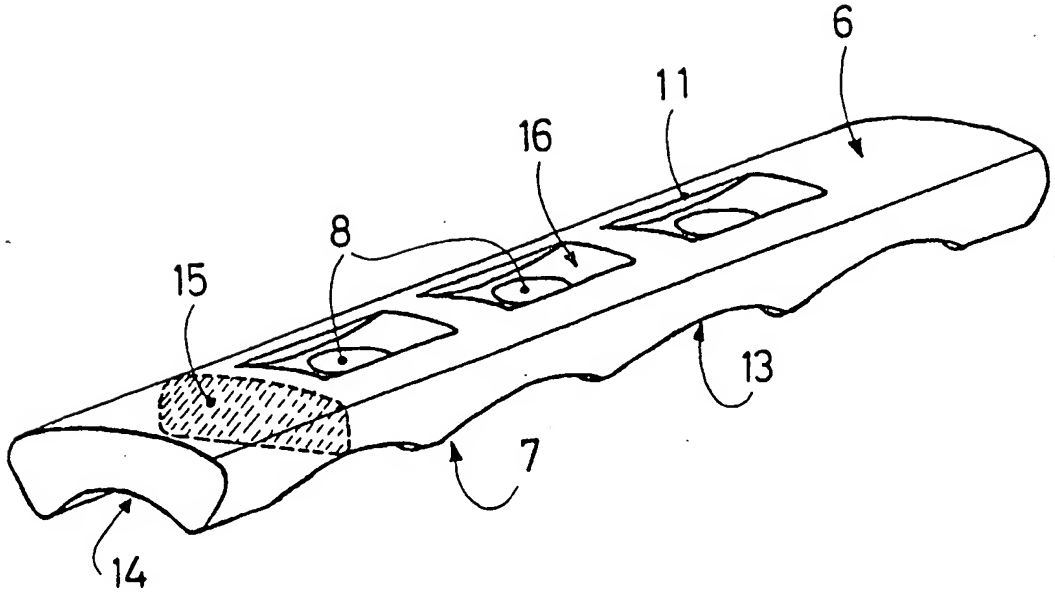

Figure 4

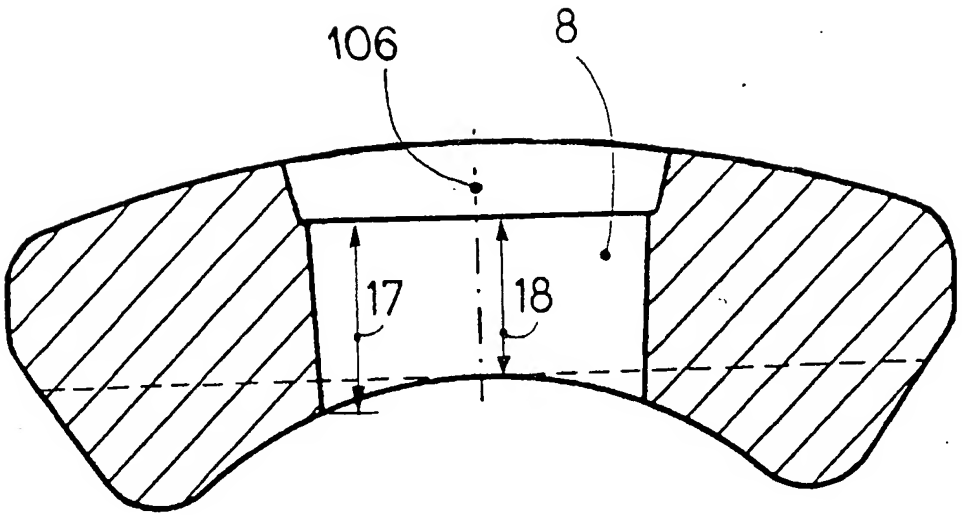

Figure 5

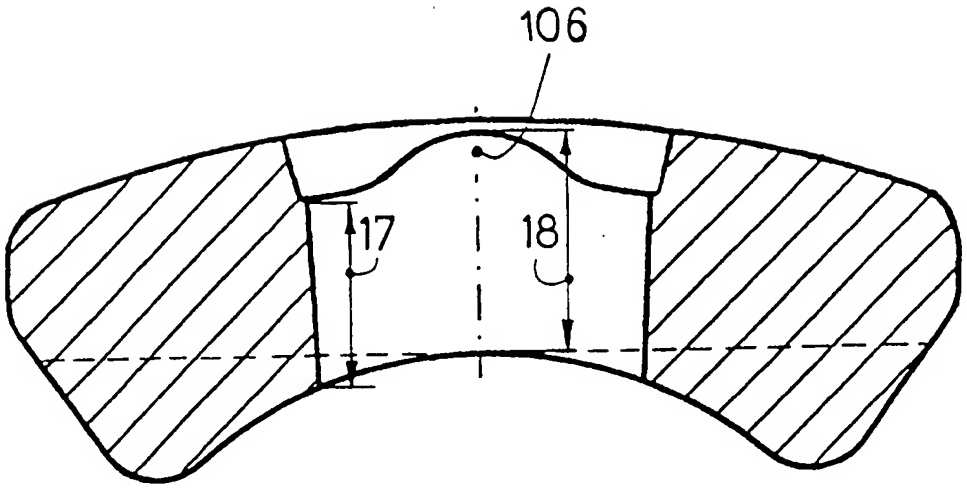

Figure 6

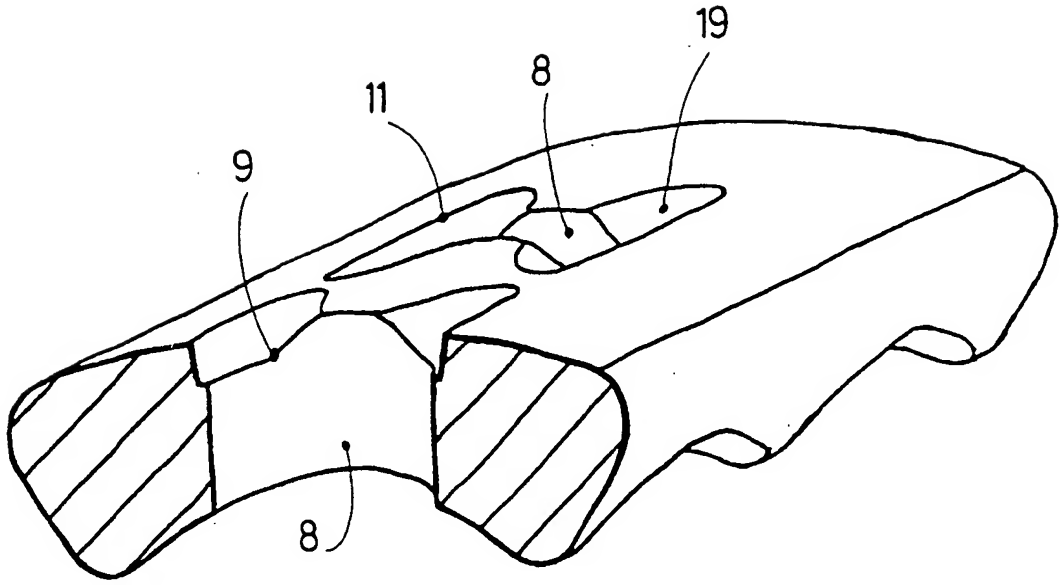

Figure 7

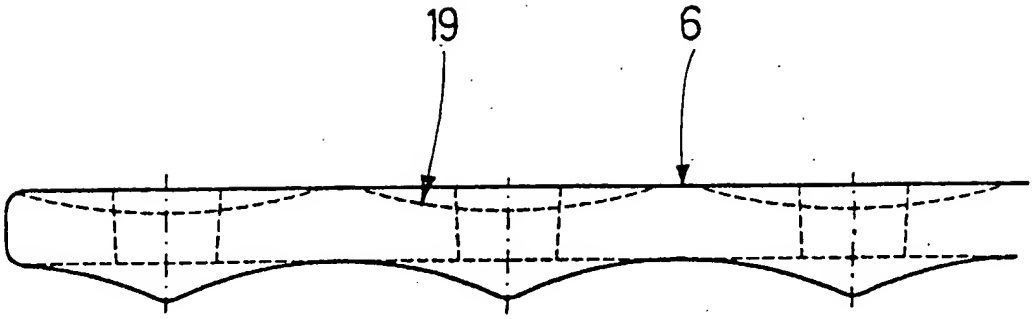

Figure 8

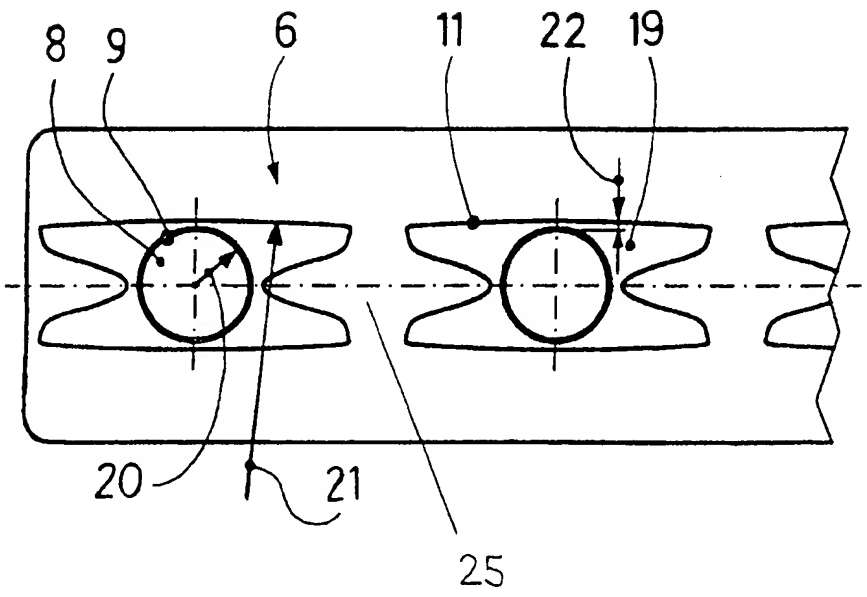

Figure 9